Sputtering yield and defect energy level characteristics MgO protective layer according to O_2 partial pressure in AC-PDPs

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Abstract

We have investigated the sputtering and secondary electron emission characteristics of MgO protective layer according to the O_2 partial pressure. The MgO layer have been deposited by electron beam evaporation method and have varied the O_2 partial pressure as 0, $5.2x10^{-5}$, $1.0x10^{-4}$, and $4.1x10^{-4}$ Torr. It has been known that the secondary electron emission coefficient and the number of defect energy levels increased as the O_2 partial pressure increases. So we have investigated the property of sputtering yield according to the O_2 partial pressure. We have known that the sputtering yield deceases as the O_2 partial pressure increases by using the FIB system.

1. Introduction

MgO is used as the most suitable material for a stable protective layer on the glass dielectric layer overlaying in the metal electrodes in AC-PDPs(alternating current plasma display panel). The characteristics of MgO protective layer influence the development of AC-PDPs. Low erosion rate is related to the PDP's life time, and high secondary electron emission coefficient (gamma vaule) is related to the PDP's firing voltage, fast response, high luminous efficiency etc. In previous study we have known that high O_2 partial pressure of MgO protect layer had high γ (ion-induced secondary electron emission coefficient) and low work-function.[3] With these results, we have measured the sputtering yield to measure the erosion rate of MgO protective layer according to the O_2 partial pressure using FIB(focused ion beam) system. The sputtering yield of MgO protective layer is an important parameter that determines the lifetime of PDP. For measuring sputtering yield, there are bunch of analysis results for sputterd secondary particles from ion beam by FIB system. These secondary particles, when injected onto the specimen surface with enough energies, induce various effects, such as sputtering of neutral atoms, emission of positive or negative ions of the substrate material and surface reflection of the injected ions due to collisions with substrate ions or atoms.

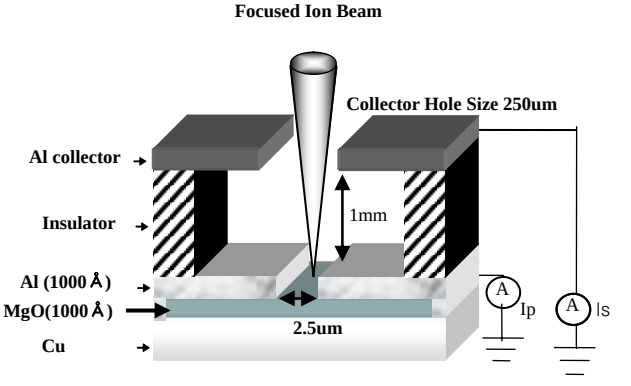


Figure 1. Schematic diagram of the beam current measurement.

2. Experimental Configuration

The MgO layers have been deposited on the Cu substrate by electron beam evaporation method and evaporation conditions were that deposition rate was 5 Å/s, the deposition temperature was 200℃, and vacuum annealing process conducted 300℃, 30min. We have deposited the poly crystal MgO of 1000Å and Al layer was deposited of 1000 Å to avoid the charging effect of the MgO layer during measurements of the sputtering yields. . The probe

current was measured while a specimen of 2.5μm x 2.5μm size was being patterned. Figure 1 shows the schematic picture of the prepared sample. For sputtering yield, we have used that measure the decrease of the layers. We have estimated the number of sputtered atoms of MgO layer and obtained the net beam current which is estimation of the number of injected ions. In Figure 1, the probe current is the sum of injected ion current and secondary electron current, it does not give the number of incident ions directly. The net beam current can be obtained by measuring the secondary electron current simultaneously by a collector placed above the specimen. Ip is the probe current, and Is is the measured current of the secondary electron current. The net beam current is given by (Ip – |Is|). In this way the net beam current was measured at 10kV acceleration voltage.

Figure 2 shows the schematic of FIB system. The ion acceleration energy has been kept to be 10 keV in this experiment. The emission current was 5uA at Faraday cup.

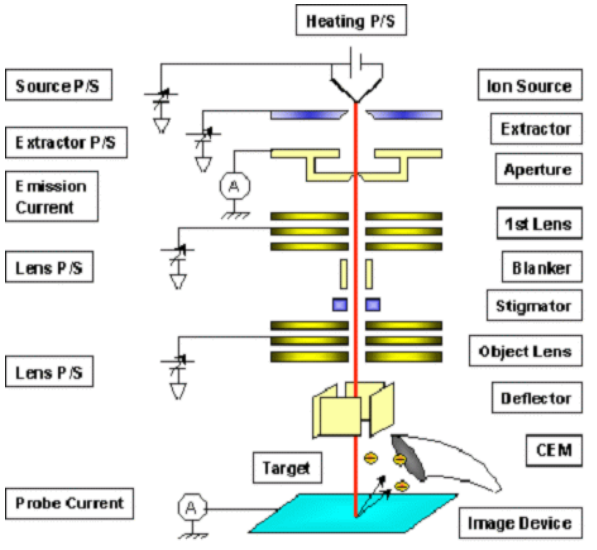
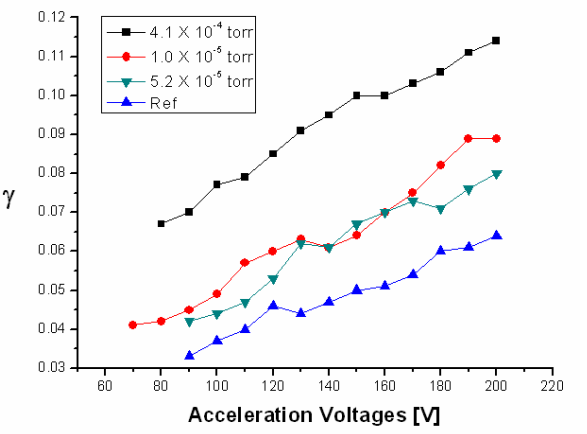


Figure2. Schematic diagram of Focused Ion Beam system.

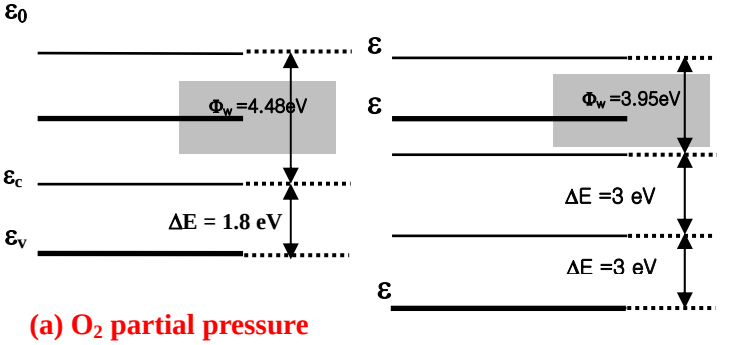
3. Results and discussion

In previous study, we had measured the γ (secondary electron emission coefficient) of MgO, work function and current signal at point of converting ion into total current. Figure 3 shows that the ion induced secondary electron emission coefficient. As the O_2 partial pressure increases, the γ vaule increases and work function decreases. Figure 4 shows that there are defect levels, located between conduction band and valence band, in MgO energy band gap.[3] For these energy levels the work function has been decreased and ion-induced secondary electron emission increased, respectively.



O_2 pressure	Ref.	$1.0x10^{-4}$ Torr	$4.1x10^{-4}$ Torr
Work function	4.48eV	4.18eV	3.95eV

Figure 3. Secondary electron emission coefficient and work function of MgO layer according to O_2 partial pressure



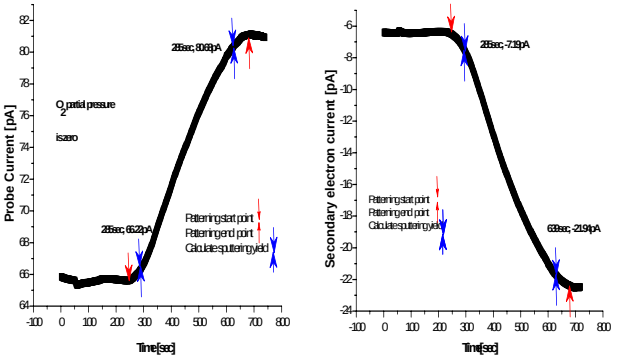
(a) O_2 partial pressure is zero

(b) O_2 partial pressure is $4.0x10^{-4}$torr

Figure 4. Energy band including defect levels

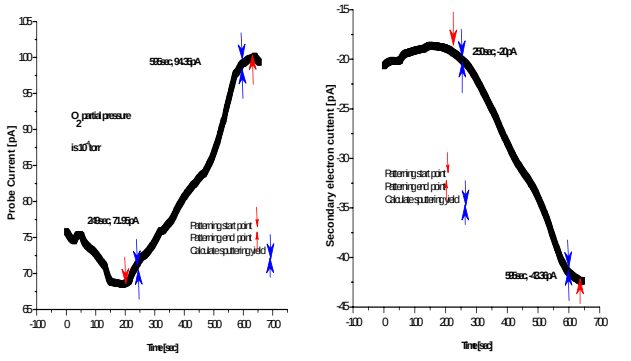
Figures 5 and 6 show the sputtered specimen current signals of MgO by Ga ion beam when O_2 partial pressure is 0 and $4.0x10^{-4}$ Torr, respectively. The starting points refer to the time when the MgO layer

begins to be sputtered by Ga ion beam. The sputtered MgO (secondary particles) reaches collector (copper) just after the Al layer, whose thickness is 1000A, sputtering is finished.



(a) Probe current (b) secondary electron current

Figure 5. Probe current and Secondary electron current of MgO, when O_2 partial pressure is zero



(a) Probe current (b) secondary electron current

Figure 6. Probe current and Secondary electron current of MgO, when O_2 partial pressure is 10^{-4}torr.

We discriminate the sputtering region between the location of the rising point, defined by the 10% location of the maximum probe current, and the end point, defined by the 90 % location of the maximum current. The sputtering yield can be estimated from the number of atoms within the sputtered volume of MgO layer and from the number of incident Ga^+ ions. The number of sputtered atoms in the MgO layer can be determined in consideration of the density and volume of the layer. The density of the MgO layer is 3.58×10^{-12} g/um^3, the mass of the sputtered volume is estimated to be 2.237×10^{-12} g when the density is multiplied with the patterned volume. Dividing it with the MgO mass (6.695×10^{-23} g) and then the number of the MgO atoms is estimated to be 3.34×10^{10}. We have obtained the incident Ga ions by measuring the net beam current and sputtering time.

We have measured the sputtering yield Y (= sputtered MgO atoms / incident Ga+ ions) of MgO layers according to O_2 partial pressures. Tabel 1 shows the sputtering yield when acceleration voltages was 10kV.

O_2 pressure	Ref.	1.0x10^{-4} Torr	4.1x10^{-4} Torr
Sputtering yield	0.21	0.15	0.11

Table 1. Sputtering yield according to O_2 partial pressure.

We have known that the sputtering yield decreases as the O_2 partial pressure increases.

4. Summary

We have investigated the characteristics of MgO protective layer during the e-beam evaporation according O_2 partial pressure. We have known that the secondary electron emission coefficient (γ), work function, defect energy levels and sputtering yield become varied by the O_2 partial pressures. With these results we have expected O2 partial pressure influenced the property of MgO layer during the e-beam evaporation deposition.

5. References

(1 line spacing)

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